

There are some things in amateur radio that we just take for granted. They're so close, so obvious, that we cease to see them as breakthroughs, nor do we think about who could have set out to invent them. Harry Rubinstein is a name you may not have heard of before, but you probably use his inventions every day of your life.

Harry W. Rubinstein, ex-9EEV (SK) Inventor of the Printed Circuit

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We owe a great debt of gratitude to those experimenters who came before us. Collectively, their inventions and contributions make amateur radio one of the most technically sophisticated, wireless, people-to-people communications services available today. But it wasn't always like that. In the early years of radio, and continuing through WW II, the potential that lay within the medium known as "radio" was only beginning to be tapped. One of those experimenters who "pushed" the state-of-the-art at every turn was Harry Rubinstein. It is with great pleasure, then, that we present the story of his life and of some of his many inventions, some of which we all use every day of our lives. The information presented here not only is based on the archival literature, but also on Ted Cohen's many discussions with Harry, his uncle, discussions that date from the early 1950s until Harry's death at the age of 85 in August 1990.

—K2EEK

Harry W. Rubinstein was born in Phillips, Wisconsin in 1905. The second oldest of five children, he showed an early interest in the new science of radio, and it was only a matter of time before he put his own amateur station on the air in the early 1920s. The Department of Commerce's call directory for 1925 (Ref. 1), for example, shows the callsign "9EEV" assigned to Harry Rubinstein, with station power listed as 5 watts.

Given Harry's intense interest in electronics, it was only natural that he attended the University of Wisconsin in Madison to obtain a BSEE. To help pay for his col-

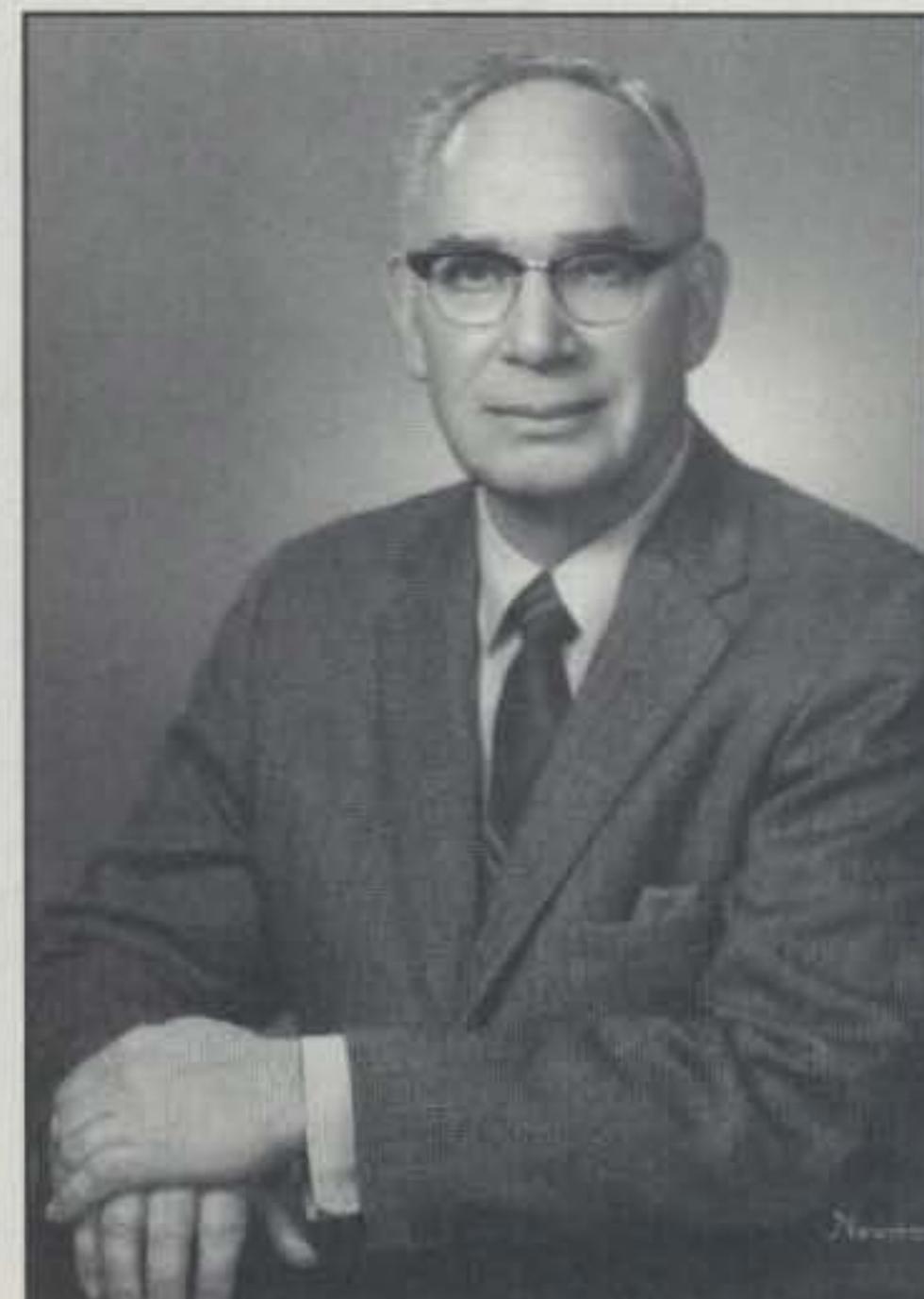
lege education, Harry worked summers as radio operator on ships that plied Lake Michigan. He graduated in 1927, and immediately took a job with Centralab Electronics Division (CRL), a division of Globe Union, Inc. (now Johnson Controls, Inc.) in Milwaukee, Wisconsin. There he rapidly rose to the position of Chief Engineer. It was as an employee of CRL that he invented devices such as the combined on-off/volume control switch for radios as well as the slide volume control. These were among the first of 20 patents Harry received during his lifetime.

Using Harry's patents (which he assigned to them), CRL produced tone and volume controls for radio receivers. The controls essentially employed a carbon-filled paste that was screen printed on a substrate; the paste, once dried, provided the resistive element for the control of tone or volume. (Ref. 2, p. 5) Harry also was very familiar with the use of screened silver, because CRL was producing mica capacitor electrodes using this technique (as opposed to the old technique of spraying silver oxide on a mica). He learned the art of using screened silver for making capacitors when the U.S. government required the Erie Resistor Company, which held the patents for making "button" mica capacitors, to establish a second source for their capacitors. Erie chose CRL, and Harry, as Chief Engineer at CRL, was responsible for the effort.

Now in place were all of the elements that would lead to one of the most important inventions of the 20th century—the invention of the printed circuit.

Invention of the Printed Circuit

Prior to the entry of the United States into WW II, the National Defense Research Committee (NDRC) undertook the devel-



Harry W. Rubinstein, ex-9EEV (1905-1990), inventor of the Printed Circuit. (Photo courtesy Mrs. Else Rubinstein)

opment of proximity fuses for bombs, rockets, and mortar shells. The Centralab Electronics Division of Globe Union was one supplier of such fuses to the Army and Navy. But by early 1944, at a time when the U.S. was contemplating the invasion of Japan, the demand for smaller and smaller fuses (driven by the increasingly small size of nonrotating radio fuses for trench mortars [Ref. 2, p. 6]) imposed almost impossible constraints on the dimensions for these devices. In fact, Harry Diamond of the National Bureau of Standards wanted a fuze developed for the 81 mm mortar shell that was one-third

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Rubinstein as a radio operator aboard the Carolina (ca. 1925). (Photo courtesy Mrs. Myrtle Rubinstein Cohen)

the size of those used in larger munitions such as bombs.

By that time, clock mechanisms not only were too big for the job, but they were not good enough. And because the fuses then built had to be hand-wired, production rates were woefully low. Diamond called upon Jacob Rabinow (a prolific inventor in his own right) to lead the development effort that would result in a small, dependable fuze for the 81 mm mortar. He also called Rubinstein to Washington, asking him to bring a contingent of engineers with him. In May 1944 Rubinstein arrived in Washington with Herbert L. White (ME), Edwin T. Sherwood (EE), George M. Ehlers (ChemE), and J. F. Harper (VP Engineering). (Ref. 2, p. 6)

At the NBS, Diamond briefed Rubinstein's group. And while they didn't understand all of the material that was presented to them, they certainly grasped the nature and significance of the problem. After many hours with the NBS personnel, Rubinstein's group retired to their hotel. They worked late into the night, but by the time they went to bed, they did not have even an inkling as to how to solve the problem of how to develop a small, dependable fuze. (Ref. 3)

The following morning Rubinstein suddenly had an idea. He asked for a copy of the circuit diagram his group was to address. Security considerations prevented Diamond from giving Rubinstein the schematic, but he did allow Rabinow to sketch portions of the circuit that involved the use of passive components. What follows below was recorded by Cadenhead and DeCoursey in their 1984 interview with Rubinstein. It is included here, word for word, because of the far-reaching implications Rubinstein's work was to have on the entire field of electronics.

"Rubinstein suggested they start with either a steatite or titanate plate and use silver patterns in place of copper wires for conductors. 'Where resistors are needed,' Rubinstein said, 'we will screen on resistors.' For capacitors the group suggested discs with silver electrodes so they could be soldered on their bottom side to the substrate and connected from the topside with a pigtail lead. **This was the first time Centralab (or anyone else) had even considered the solid state integration of passive circuit elements; and, in fact, their results were the first of its kind thick film microelectronic circuitry . . .**" (emphasis added; Ref. 2, p. 6)

The suggestions of Rubinstein and his group were immediately embraced by Diamond and his staff at NBS, and they urged the CRL personnel to develop a prototype device as soon as possible. This they did, and within a week Rubinstein returned to Washington with two prototypes: One used steatite as a base and the other used titanate. He gave the printed circuits to Rabinow, who immediately added the missing components and tested the devices (remember, Rubinstein's group was not allowed to take a complete schematic with them). According to conversations with Rubinstein (personal communications), only the circuit that used steatite worked. This is confirmed by Cadenhead and DeCoursey (Ref. 2, p. 7), who remarked that Rubinstein heard Rabinow shout as he came out of his laboratory: "It works! It works!" Rabinow then directed Rubinstein to return to Milwaukee and perfect the steatite-based circuit. This circuit, once perfected, became the prototype for fuses that CRL, using the facilities of the South Lowell, Massachusetts, ordnance depot, turned out at the rate of 100,000 per month.

The Post-War Years

In 1946 Rubinstein and two colleagues left Globe Union and formed Herlec, Inc., which specialized in manufacturing ceramic capacitors. Sprague Electric subsequently purchased Herlec in 1948 and retained Rubinstein to run their Grafton, Wisconsin factory. It became the most profitable cost center in the entire corporation. According to his granddaughter, Marge Rubinstein Eiseman, he instinctively knew how to do many things, a capability that led to a saying at Sprague that

"[T]here's a right way, a wrong way, and Harry's way" for getting things done! (personal communication)

Forced into retirement in 1971 at age 65, Rubinstein continued to tinker with electrical and mechanical devices. He was an avid collector and restorer of French carriage clocks and maintained an active correspondence on the subject of complex locks with his old friend Jacob Rabinow. He again became a serious (and successful) student of the stock market, an area in which he had an intense interest throughout his life. He also liked to fish, make jewelry, play bridge and the piano, and travel. Even when a stroke in 1983 left him paralyzed on the right side, Rubinstein continued to create devices of one sort or another. Unable to open and close a sliding glass door to his bedroom, for example, he designed and built a remote-controlled device to do the job.

It was through the untiring efforts of his friend and fellow inventor Jacob Rabinow that Rubinstein was nominated for the prestigious Cleo Brunetti Award by the Institute of Electrical and Electronics Engineers (IEEE) for his invention of the printed circuit. After much research, the Institute agreed that indeed, Rubinstein was the inventor. The award, which was officially announced in February 1984, was for his lifetime "outstanding contributions in the field of miniaturization in electronic arts" and specifically, for his invention of the printed circuit. Despite having suffered a stroke in early 1983, Rubinstein traveled to California later in 1984 with his wife, Else, to accept the award and to receive a standing ovation from 3100 engineers at the IEEE's annual convention.

Epilog

Rubinstein never benefitted financially from his invention of the printed circuit. Because his invention, made during wartime, was considered so important to the war effort, he was not permitted to file a patent application for over 20 years. And even when he did file, the patent had to be assigned to Globe Union. For his invention of the printed circuit, and in line with business practices found even today in the United States and elsewhere, Globe Union paid Harry Rubinstein \$10. ■

References

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3. Greene, Laura, *Computer Pioneers*, Franklin Watts, New York, 1985, p. 56–59.